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Cesar Meneses  
*Arizona State University*

J. René Villalobos  
*Arizona State University*

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# **Determination of Operational Parameters for an Efficient Container Service in the Port of Guaymas**

**Cesar Meneses and J. René Villalobos**  
**International Logistics and Productivity Improvement Laboratory**  
**Arizona State University**  
**Tempe, AZ 85287**  
<http://ilpil.asu.edu>

## **Abstract**

The port of Guaymas is located in Sea of Cortez in the Northern Pacific Coast of Mexico. Its hinterland is basically the Northwestern region of Mexico and the Southwestern United States. The Port currently focuses on bulk and liquid cargo and does not provide container services. In this paper, we explore some of the characteristics that a container service should have to be competitive in servicing the needs of the regional industry. Since the study deals with port selection decision from the industry's point of view, we introduce a port selection model based on a Total Landed Cost (TLC) metric. The findings show that under the right conditions, the Port of Guaymas is an attractive option for the companies located in its hinterland.

## **1 Introduction**

The Port of Guaymas is located in the Sea of Cortez in the Northern Pacific Coast of Mexico. It is the main sea port in State of Sonora and one of the biggest ports in the Pacific coast of Mexico. Figure 1 shows the Geographical position of the port. The port has been active for centuries and its main activity has consisted of handling of inbound and outbound bulk cargo -such as mineral and liquid- [1]. Its extended hinterland is composed by the northwestern states of Sonora and Chihuahua in Mexico and parts of the states of Southern Arizona, Southern New Mexico and West Texas [2]. Figure 2 shows the map of the identified hinterland.

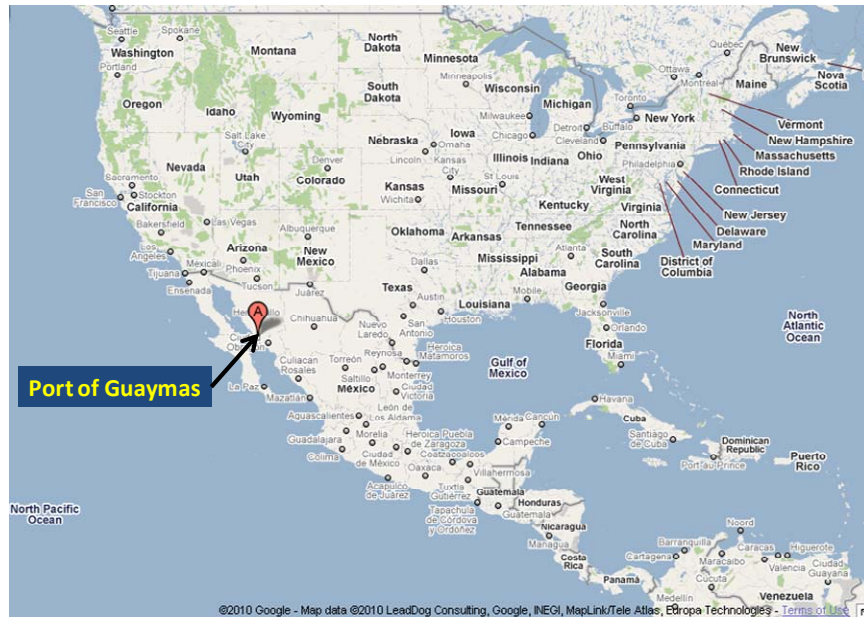


Figure 1 - Geographic Location of the Port of Guaymas, Mexico

Since the Port of Guaymas does not provide container services, the local industry has to use the container services provided by other ports such as the Ports of Long Beach, Los Angeles, and at a lower scale because of connectivity issues, the Port of Ensenada in Baja California, Mexico. This lack of a container services in Guaymas may be affecting the economic development of the region since some companies may prefer to locate in some other places with access to efficient container services.

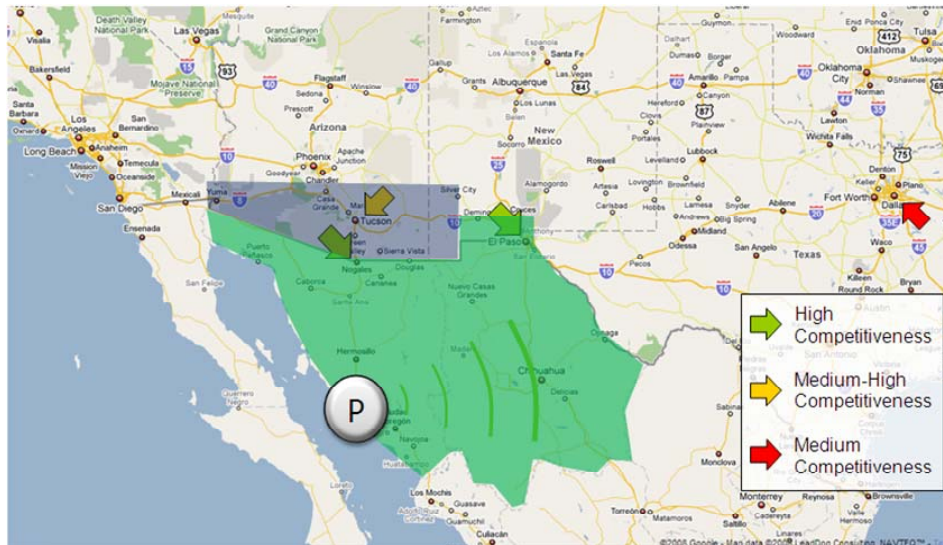


Figure 2 - Port of Guaymas Extended Hinterland

Villalobos and Sanchez in a previous study [3] determined that the existing infrastructure, as well as the transportation links between the Port and its hinterland could support the handling of 175,000 TEUs (twenty-foot equivalent unit). The present paper explores the conditions under which a container service in the Port of Guaymas would be beneficial for the companies already in the region of influence of the Port. In particular, we build a model to estimate the current total landed cost for a container shipment of a prototype company operating within the region of influence of the port. Once this cost is determined we explore different scenarios under which the Port of Guaymas could offer a competitive container services. The underlying hypothesis is that adding a container service through the port of Guaymas could have a positive impact on supply chains of the local companies by reducing the transportation lead time variability with the resulting reductions of total landed costs. This reduction in variability is dependent on having efficient port operations by which the containers are handled appropriately to be delivered within reasonable time windows. We tackled this issue in the second part of this paper.

The remainder of the paper is organized as follows; Section 2 provides an insight on the overall problem. Section 3 briefly describes the methodology applied. Section 4 presents the analysis and results. Finally, section 5 discusses the conclusions and presents some suggestions for future research.

## **2 Problem Description**

The first problem tackled in this paper is the determination of the conditions under which the operation of a container service in the Port of Guaymas would result in savings on total landed costs experienced by companies based on the hinterland of the Port. The second problem is to make recommendations to the Port in terms of its operations to materialize these savings. In particular, we make recommendations regarding storage and handling of containers within the port to meet the operational parameters that result on reduced total landed costs. Before going into the specific details of these two problems we present additional background next.

### **2.1 Profile of Potential User of Container Services**

The first step of the process of determining the potential savings resulting from a container service in the Port was to determine the profile of a “representative” product being imported or exported by a “representative” industry from the region of study. In particular, we focused on the industry with commercial operations with the countries of Far East Asia, which are the most likely to use the ports of LB/LA. Based on information obtained from different sources [4], the representative industry of the area was determined to be a *maquiladora* (manufacturing companies whose most of their output is exported) in the automotive, aerospace, electronics or machinery manufacturing segments, which represents about 70% of the manufacturing base of the region. Based on

information obtained by searching on import/export records between Asia and the region of study [5] it was determined that most of the products being shipped by container consisted of electronic, metal-mechanic and plastic components and assemblies, as well as raw metal and plastic.

Once the previous profiles were identified, a map of the typical transportation networks used to move these products was created based on different interviews with key elements of the participating companies. Figure 3 shows a schematic of these networks.

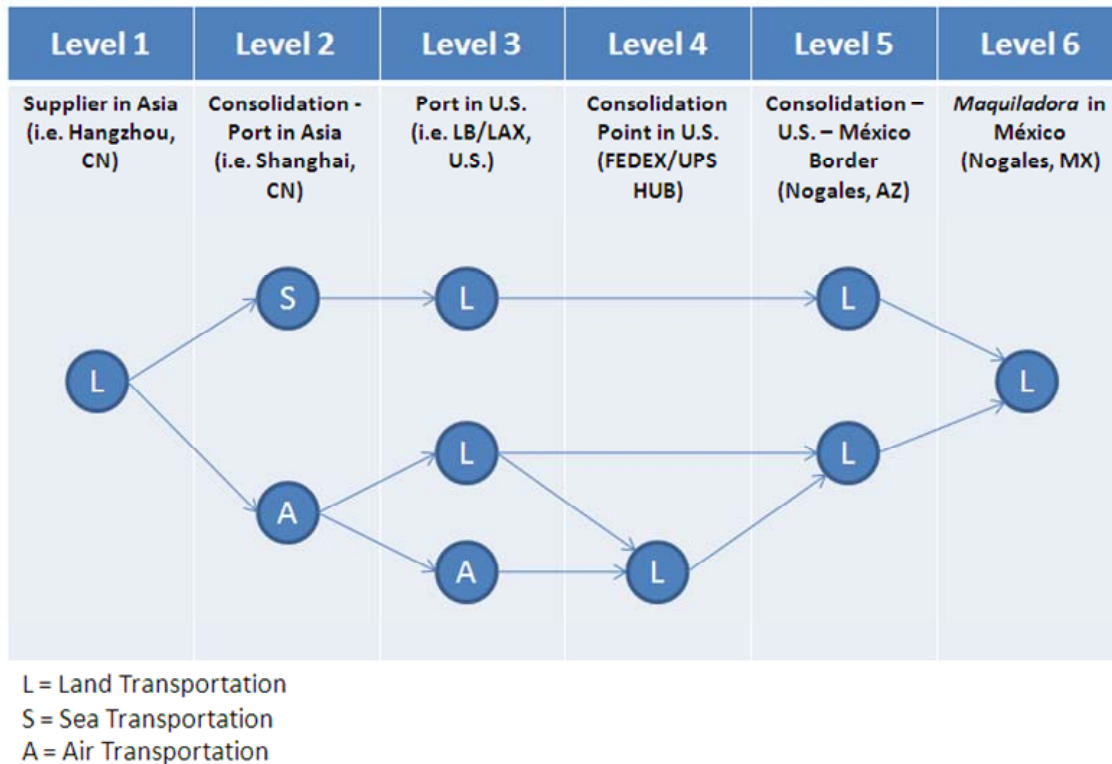


Figure 3 - Typical Transportation Network of the Representative Industry Supply

## 2.2 The Opportunity for the Port

Once the transportation networks were mapped, an analysis to find the most critical links of the networks was performed. This was accomplished by analyzing time and cost data and interviewing technical personnel of the representative companies. The results of the analysis show that the level 3 of the Network depicted in Figure 3 is the most variable segment of the transportation network. This finding is consistent with other studies [6] [7] [8] [9] [10] which have found that the variability of servicing the ships and their containers at the ports is a significant problem in the supply chains of different industry segments. This has been particularly the case in the Ports of Long Beach and Los Angeles which historically have presented high levels of service variability in some of the months of the year. Since most of the container traffic that has an origin or destination in the

region being studied use these ports, we hypothesized that an area of potential competitive advantage for the Port of Guaymas would be the reduction of this variability for the containers in and outbound from its hinterland. Thus, the problem from the Port's Administration perspective is then to define the proper parameters of operations to provide a service that would translate this potential opportunity into a specific container service.

### 3 Methodology

The underlying factor of the problem being analyzed is service time variability. In particular, we attempt to capture the effects of lead time variability on the overall supply chain costs. In order to achieve this, a total landed cost model was used to integrate the cost components derived from port operations variability. This total landed cost is then used to support logistics decisions. Figure 4 shows an outline of the overall methodology.

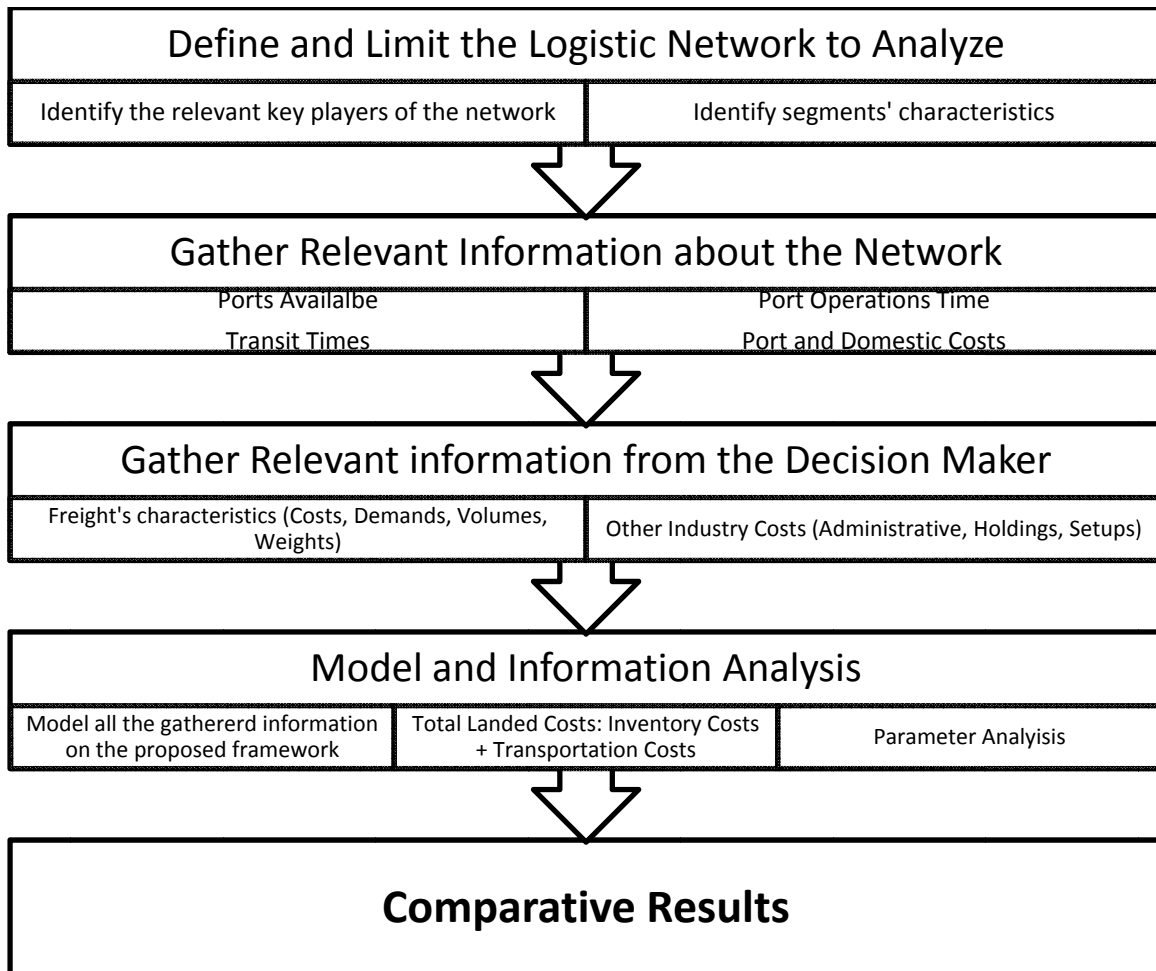


Figure 4 - Methodology Outline

In particular, the total landed cost metric for this methodology is defined as:

Year Total Landed Cost =

$$\text{Order Cost: } \left(\frac{D}{Q}\right) * S +$$

$$\text{Transportation Cost: } R(Q) * D +$$

$$\text{In – transit Inventory Cost: } \frac{ICDT}{365} +$$

$$\text{Carrying Cost of Regular Stock: } \frac{IC'Q^*}{2} +$$

$$\text{Carrying Cost Safety Stock due Transportation: } IC * s'_t +$$

$$\text{Stock Out Cost: } \frac{D}{Q^*} * ks'_d E(z)$$

Where:

D = Year Demand

S = Order Setup Cost

Q = Order Batch Size

R(Q) = Transportation rates as function of Q

I = Opportunity Interest

C = Product Unit Cost

T = Total Time of Transportation

$s'_t$  = Transportation Standard Error

k = Stock out penalty factor

We are particularly interested in the last two components of the previous equation; namely, the carrying cost of the safety stock and the cost of stock outs. The variability of service time at the ports directly affects these two cost components.

## 4 Analysis and Results

In this section of the paper the results of the analyses are presented. The first analysis consisted of determining under what conditions a container service at Guaymas would be competitive vis-à-vis the services offered by other ports. Based on the results of the first analysis we then explored different container yard configurations that would allow the Port of Guaymas to achieve these competitive conditions.

## 4.1 Achieving a Competitive Position for the Port of Guaymas

The analysis to determine the Port of Guaymas competitive conditions focused on finding the levels of service time variability that would result on lower total landed costs for its potential customers than those from the competing ports. Based on these results, suggestions were made in relation to the operational parameters that the Port had to meet regarding the handling containers within its facilities. In turn, this serves to determine some general design guidelines for the container yard of the Port.

In order to determine the variability bounds that would make the operations of a container terminal in the Port of Guaymas attractive we need to determine the variability observed on those ports that are regularly used by the potential customers. Specifically we are interested on the ports Long Beach and Los Angeles (LB/LA) and the Los Angeles Cargo Terminal (LAX), shown in Figure 5 as level 3.

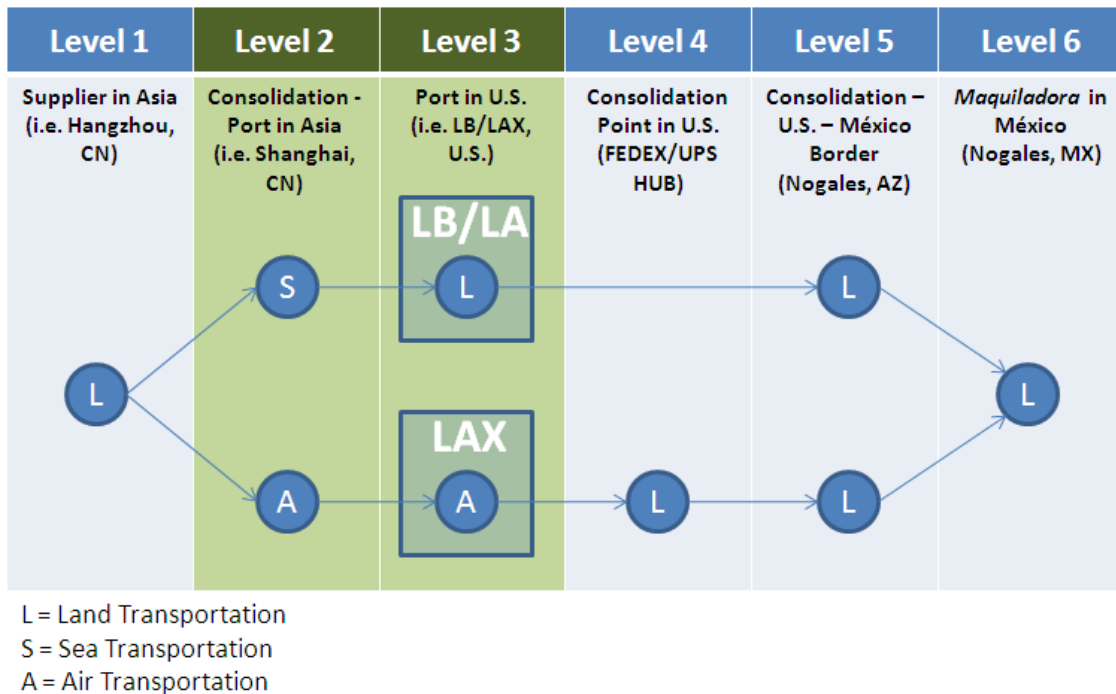


Figure 5 - Delimitation of the Segment to Analyze

Table 1 shows the specific variability observed for container shipments from Shanghai to each of the ports of interest. The variability is shown in terms of days for different service levels for each one of the routes. For instance, based on the data shown in Table 1 for a 95% service level, the total time from the time a container is shipped from Shanghai to its release in the destination port was estimated to be 17.3 days, when average time is 14 days. This 3.3 day difference represents for the consignee additional



costs in the form of safety stocks and/or stock outs. The costs are even higher when the required level of service increases. Therefore, the lower the variability in container delivery times (travel + unloading + handling), the lower the additional costs for the consignee.

Table 1 - Variability per Port at Specific Service Levels

<i>Port:</i>	<i>LB/LA</i>	<i>LAX</i>
Average Lead Time "D":	14 days	1.54 days
<i>Service Level [P(X&lt;D)]</i>	<i>Additional Days</i>	<i>Additional Days</i>
90%	2.32	0.12
95%	3.30	0.16
99%	5.41	0.23

The values shown in Table 1 were used to quantify the level of variability observed at each port. The next step was to define scenarios of different shipment profiles to transform the observed variability into costs. Table 2 shows the scenarios.

Table 2 - Scenarios Used on the Analysis

<i>Scenario (Profile)</i>	<i>Weight (Kg/unit)</i>	<i>Cost of unit(USD)</i>	<i>Demand (Units/Year)</i>
1	1	\$ 5.00	10,000
2	1	\$ 5.00	500,000
3	1	\$ 150.00	10,000
4	1	\$ 150.00	500,000
5	20	\$ 5.00	10,000
6	20	\$ 5.00	500,000
7	20	\$ 150.00	10,000
8	20	\$ 150.00	500,000

The previous scenarios and the estimated variability of each port were input into the Total Landed Cost model previously described. A general outline of the steps followed to arrive to total landed costs consists of:

- (1) Set a target service level (90%, 95%, 99%)
- (2) Select a scenario to compute costs
- (3) Select the Port (LB/LA or LAX)
- (4) Input Data (lead time variability, scenarios, port and transport tariffs, setup costs, order quantities) into the TLC model
- (5) Compute Yearly Total Landed Cost

Iterations were performed until all the costs for the ports, service levels and scenarios were obtained. Once this information was available we used it to estimate

Guaymas' total landed cost as a function of lead time variability. This process consisted of the following steps:

- (1) Set a target service level (90%, 95%, 99%)
- (2) Select a scenario
- (3) Select the Port to compare (LB/LA or LAX) and its computed TLC
- (4) Fix an assumed variability time (in days) for the Port of Guaymas (i.e. 10 days)
- (5) Input Data (scenarios, port and transport tariffs, setup costs, order quantities) into Guaymas' TLC model
- (6) Subtract the obtained the two TLCs (Selected Port – Port of Guaymas) and record the result
- (7) Reduce the assumed variability time for the Port of Guaymas (-0.5 days)
- (8) Go back to (5) and recalculate

The results of interest are those where the TLC of Guaymas are lower to those observed from using the other ports. Figure 6 show an example of the resulting savings of shipping the product defined by scenario 8 through the ports of Long Beach (fixed variability) vs. Guaymas (variability days along the X axis). This graph shows the range of variability levels for which the Port of Guaymas would be competitive vis-à-vis the Port of Long Beach.

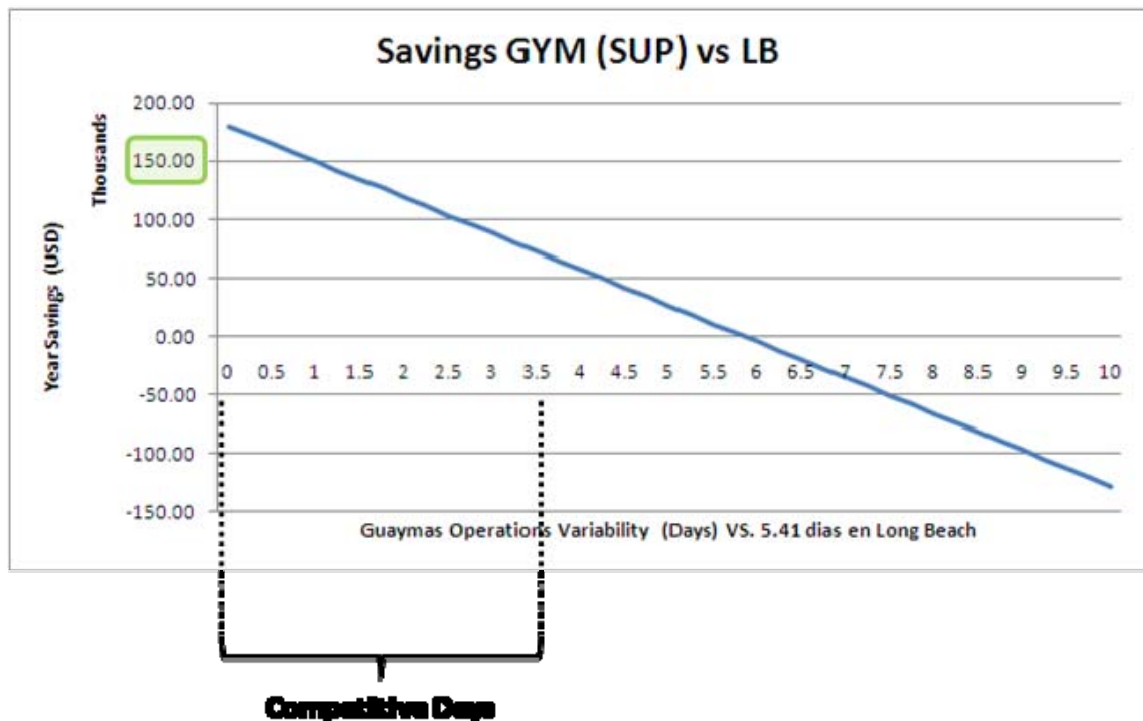


Figure 6 - Graphic TLC comparison for Scenario 8

Figure 7 shows the TLC as function of the variability and the shipment's unit cost. In this figure we can see the combination of parameters that result on lower costs for containers shipped through Guaymas.

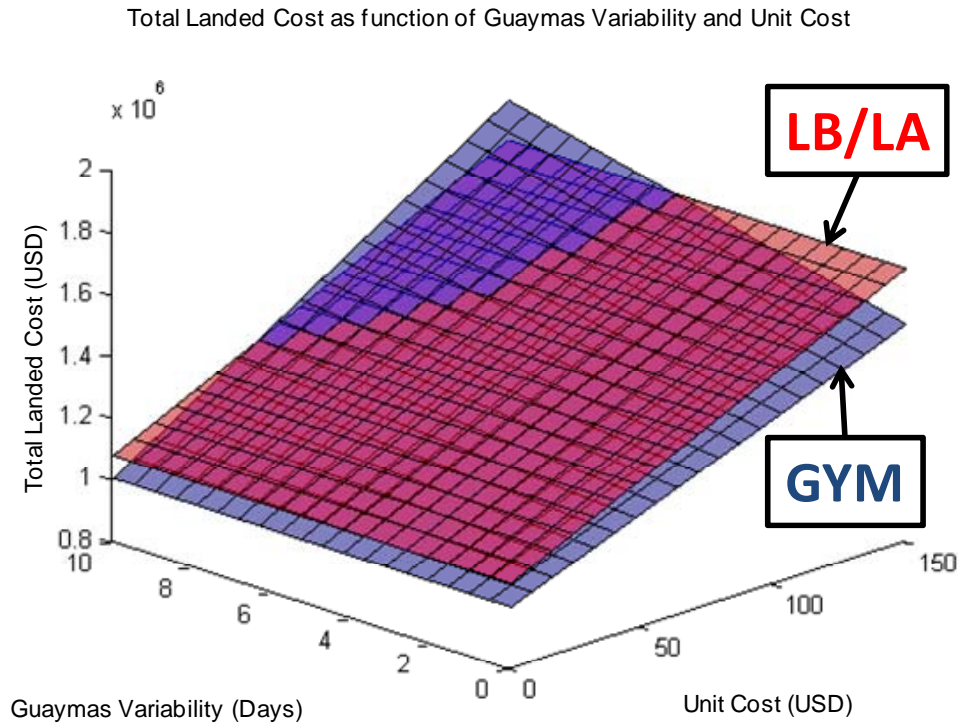


Figure 7 - TLC as function of Guaymas Port Variability and Shipment's Unit Cost

After reviewing the results for all the scenarios and based on the observed variability from the competitive ports in the supply chain of the studied region, we concluded that the Port of Guaymas could attract business from the regional industry if it provided a container processing service time between 0.5 days to 3.0 days. These values can be considered the lower and upper bounds of variability in days to be used as a reference for the potential containerized cargo service.

## 4.2 Determining the Operating Parameters of the Container Yard

Based on the results obtained in the previous section of the analysis, the next step on the study was to obtain a configuration for the yard container operations that would allow the Port of Guaymas to meet the targeted variability levels. For this objective, we estimated a potential container transit volume and compared several container yard scenarios that could effectively handle the estimated container transit within the variability bounds.

In order to estimate the potential container volume that the port could attract we obtained information on incoming shipments to the region of interest. Figure 8 shows a graphical summary of this information.

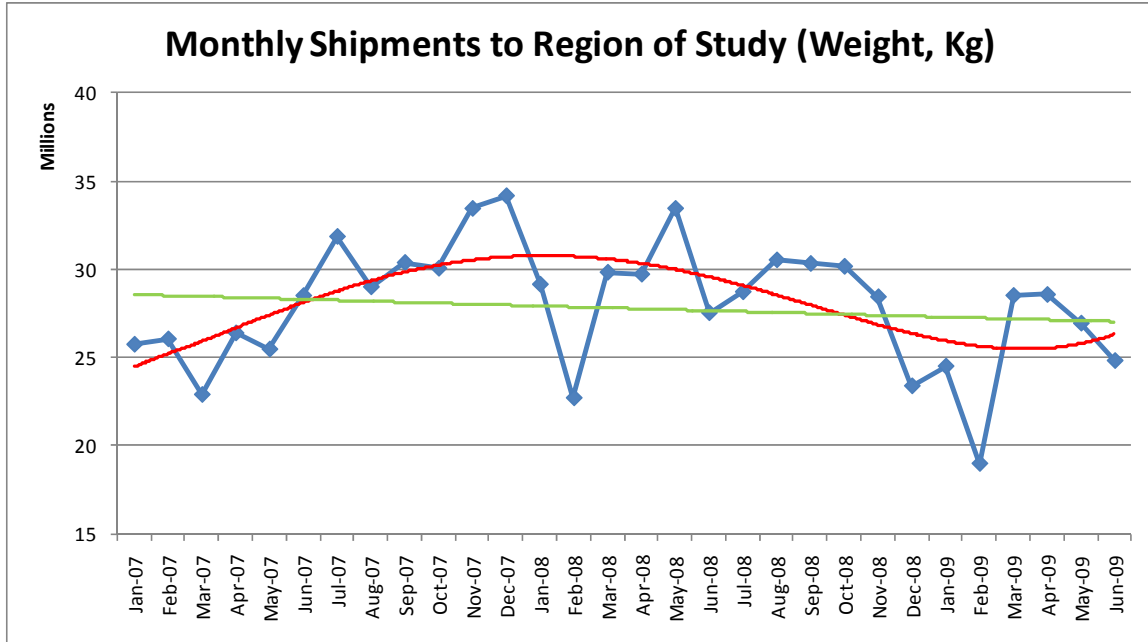


Figure 8 - Total Shipments (in Kg) to the Port's Influence Zone

Figure 8 shows that the shipments present some, but insignificant seasonality. We observed that there is an approximate container transit equivalent to 1,200 TEUs/week, considering direct and indirect shipments. From this information it was estimated that a total of 750 inbound-outbound weekly TEU could be attracted to the Port if an upper bound of 3 days for container release was maintained. These numbers were used to propose a strategy for container yard configuration and operation. The analysis of the strategy is presented next.

The space availability for a container yard in the Port of Guaymas is limited. The available area assigned for the container yard is approximately 12.35 Acres. If we considered 90% land utilization efficiency we are left with approximately 11.00 acres for container storage and handling. An aerial view of the Port and the designated container yard area is shown in Figure 9.



Figure 9 - Available Yard in the Port of Guaymas

We used the storage strategies described by Griffin and Ratliff [11] to develop the preliminary configuration of the container operations. The configurations explored are basically the wheeled, grounded and the dynamic storage operations proposed by these authors. The wheeled storage configuration is defined as one where each container is left on a chassis and stored in a designated parking lot. The grounded operation is the one where containers are stored in block-stack slots, which requires unload/load operations generally done by top lifters or a yard gantry crane. In our case we only consider the yard gantry operations. Each of these strategies was analyzed on terms of space and time required.

Figure 10 shows the suggested repeatable area for “wheeled configuration”. The area is setup for 40 ft containers. It totals 4.59 acres and the use of fractional areas is allowed.

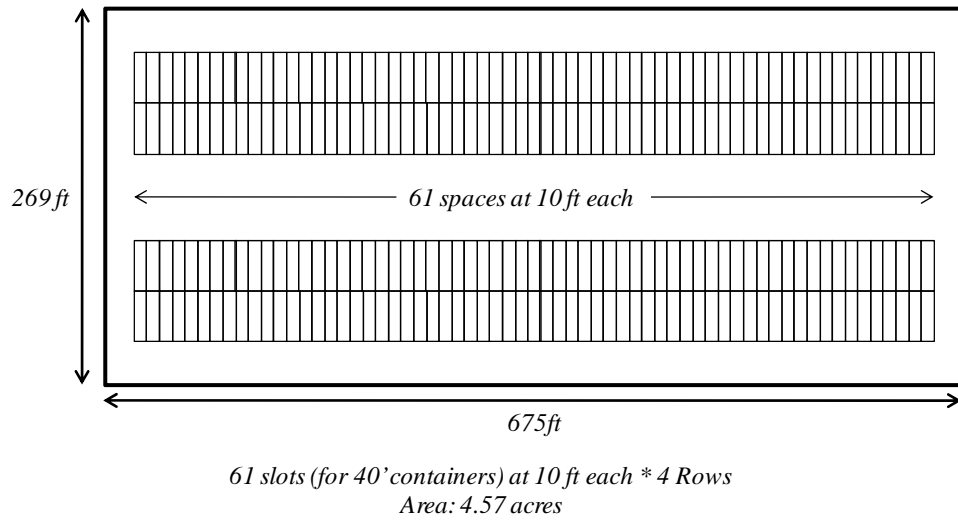


Figure 10 - Wheeled Configuration Repeatable Area

Figure 11 shows the suggested repeatable area for “grounded configuration”. The area is also defined in terms of 40 ft containers as well and it totals 6.48 acres. Additionally, each slot can be stacked 3 containers high. These areas can be served by a single yard gantry crane assuming little lateral crane movement.

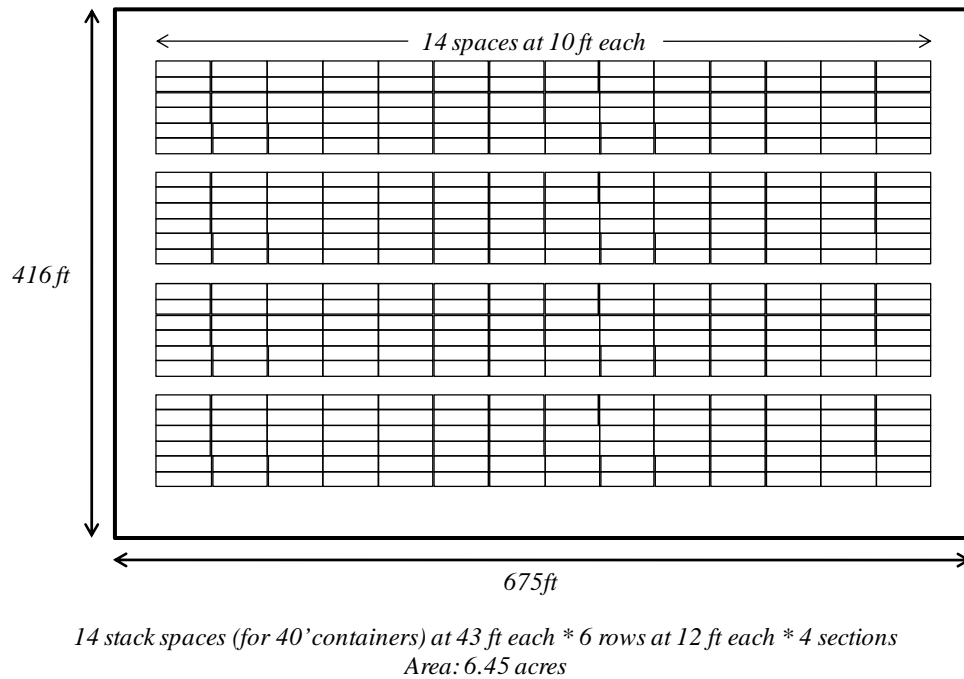


Figure 11 - Grounded Configuration Repeatable Area

The feasible layout strategies for the container yard are those who can handle the container transit –inbound and outbound- with average times lower than the bounds previously determined for Guaymas. In particular, the feasible strategies are based on the following conditions: (1) the average time to service all incoming containers is less than 3 days, (2) the average number of weekly containers (40 ft) handled by the Port are 725: 375 inbound and 350 containers outbound. 3) In steady state the average container inventory at the port was then estimated to be 435 containers per week.

The first scenario analyzed was the *wheeled only* operation strategy. Since the total available storage area was assumed to be 11.00 acres, this would limit the maximum number of repeatable areas for wheel operations to 2.41. This would render 587 container slots. Thus, based on the average inventory level of 435 containers per week, the all wheeled configuration would not be sufficient to meet the situation where the inventory at the port would exceed 587 containers. The next scenario analyzed was the *all grounded operation*, for which there is only space for one repeatable area. This scenario assumes that there is a single gantry crane servicing a single repeatable area. In this case the available container slots are defined by the stack level as follow: 1-container, 336 slots; 2-containers, 672 slots; 3-containers, 1008 slots. Again, the average inventory limits precluded us from just using 1-container stack grounded operations. The 2 and 3-container stacks were then analyzed. The obvious disadvantage of this strategy as compared to the wheeled operation was the longer retrieval times for containers since additional maneuvers would be required to access the containers in the first or second layers of the stacks [11].

The last analyzed scenario was as *dynamic operation* strategy. In this scenario, the container yard is configured as a hybrid of wheeled and grounded operation. The underlying objective for this analysis was to have a strategy that would give us the benefits of the wheeled (short retrieval time) and the grounded strategy (better land utilization). This hybrid strategy is required to yield an average service time lower than the suggested upper bound and meet the total land constraints imposed by the current configuration of the Port. The resulting final strategy was to divide the available area for the container yard in 1 wheeled and 1 grounded repeatable area (11.03 ac); then dividing these areas into outbound and inbound container operations. The resulting four zones presented in Figure 12.

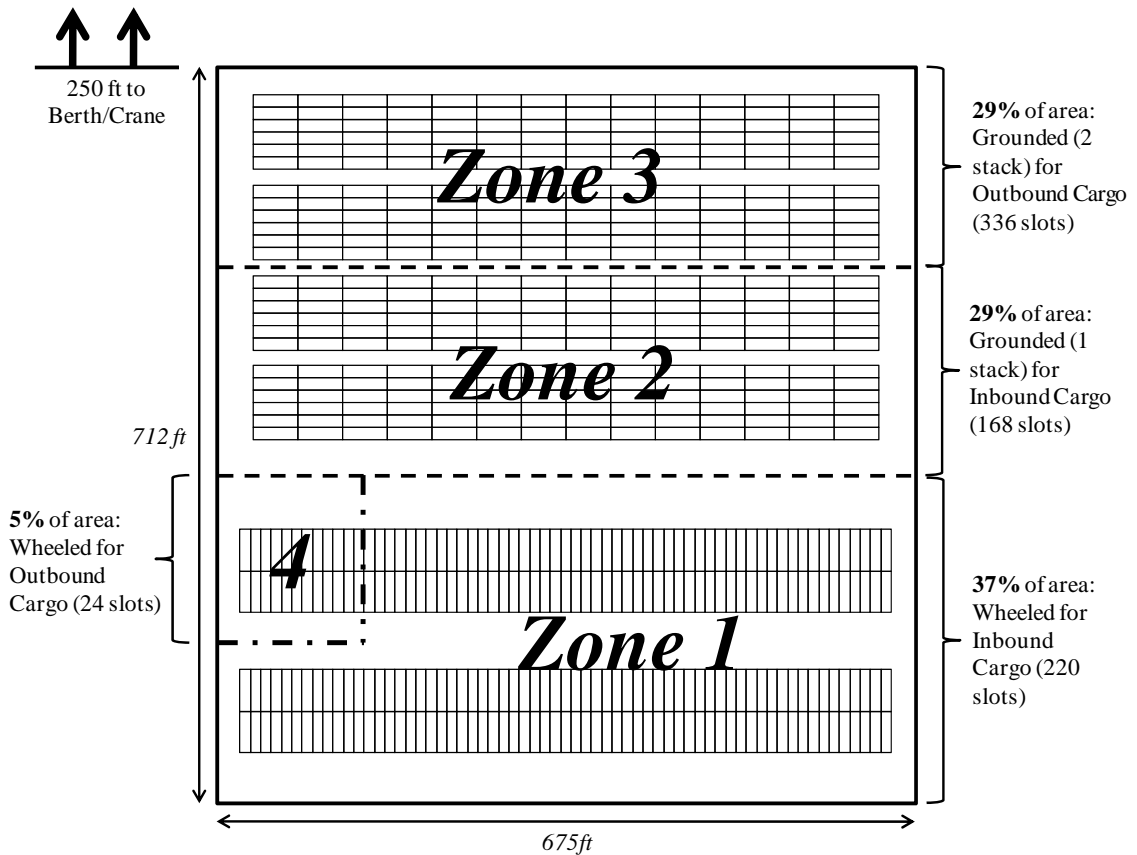


Figure 12 - Suggested Dynamic Configuration

Zone 1 is dedicated to inbound containers unloaded from the vessel that are positioned on chassis for their immediate retrieval without additional delays of intermediate moves of containers. The zone is designed to contain 220 slots. The idea is to preposition containers that scheduled for leaving the port the same day they are unloaded from the ship. Zone 2 is dedicated to inbound containers. This zone is to be configured for 1-container stack grounded operations with 168 slots available (could be potential increased up to 336 slots by using 2-container stack on an as-needed basis). It is to be used for inbound containers after zone 1 has reached its maximum capacity. Zone 3 is dedicated to outbound containers, hence their position close to the dock and quay cranes. This area is set for 2 or 3-container stack so the capacity can be up to 504 slots. This would be the first area to fill as the outbound containers arrive to the port's yard from the in-land shippers. Finally, zone 4 is allocated to outbound containers scheduled to be loaded to the vessel. This small area can be used for those containers arriving to the port in a time close to the ship's arrival. It also provides chassis flexibility during the loading/unloading operations.



The proposed yard strategy has as its main objective the quick processing of the containers. We focused on having the most inbound containers set in fast movers and keeping the berth cranes as the bottleneck of the operation. The proposed strategy could achieve a container release time of 8 hrs, and the total processing times at the Port within 24 hours, significantly below the 3 days identified as the area of opportunity for the Port of Guaymas to efficiently service the needs of the regional industry.

## 5 Conclusions

In this paper we explored the scenarios under which the Port of Guaymas is a competitive port to service the current needs of the regional industry. As part of the analysis we modeled the existing relationship between the port's service time variability and the needs of the supply chains of the potential shippers. We used total landed cost to establish the bounds for the port processing times for which a container operation in Guaymas would be competitive versus the existing container services. We also established the potential TEU traffic for the Port of Guaymas as 728 TEUs per week. We then converted these volumes and processing times into a specific design/operation for the container yard of the Port. Specifically, we recommended that the Port follow a dynamic strategy to meet the processing times and limited land availability constraints. This strategy will result on meeting a rapid turnaround of the containers and at the same time lowering the transportation variability which will result on lowering total landed costs of the potential users.

The study presented in this paper took a very broad perspective in terms of the needs of the potential users. A logical next step is for extend this study to specific shipments and levels of service for the potential users of the container services. Another study that would complement the one presented here is to take the perspective of the shipping lines to develop a port choice model that would shed light on the conditions under which the Port of Guaymas would be an attractive port of call in their schedules. From an even broader perspective, the development of models that can translate the needs of specific supply chains into design parameters is a very promising research area.

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